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(71) Applicant(s)
Orbital Traction Ltd
(Incorporated in the United Kingdom)
100D Leicester Road, HINKLEY,
Leicestershire, LE10 1LU, United Kingdom

(72) Inventor(s)
Peter James Milner

(74) Agent and/or Address for Service
Mark Shelley
K R Bryer & Company,
7 Gay Street, BATH, BA1 2PH,
United Kingdom

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(54) Abstract Title

Transmission having both CVT and non-CVT devices

(57) A transmission device 11, has a CVT 11a, eg a rolling traction drive, in combination with an non-CVT 11b, eg an epicyclic gear train. The rolling traction drive has inner and outer races 13 and 14, which separate into two parts 13a, 13b and 14a, 14b, between which are planet balls 15. Follower rollers 16, located between the balls 15 are mounted on a carrier 17 having a tube 18 which acts as one of the drive members of the device 11. The inner race 13 is mounted on the other drive shaft 20 in a manner to allow the two parts 13a,13b to move towards and away from each other. The outer race parts 14a, 14b can also move towards and away from each other via rotation of a lever 52. Variation in the radial position of the balls 15 is effected by rotation of the lever 52 which brings the upper race parts 14a,14b together and forces the balls 15 towards the shaft 20 (lower race parts 13a,13b move apart due to this force). The epicyclic gear train 11b has a sun gear 55, a number of planet gears 60, and an outer annulus gear 65. Rotation of shaft 20 also rotates the inner race parts 13a,13b which causes rotation of the balls 15, and therefore also rotation of the carrier 17 via followers 16. The rotation of the shaft 20 also rotates the epicyclic gear train 11a. In the continuously variable mode of operation, torque is transferred between the shafts 18,20 via the CVT only, because gear elements 55,60 and 65 rotate freely with respect to each other, but when the balls 15 are moved to their outermost position, the drive torque is switched to the non-CVT 11b by engagement of a locking member 68 to the annulus 65. In 'this top gear' configuration torque is transferred between the shafts 18,20 by both the CVT and non CVT until the balls 15 are completely disengaged by further rotation of lever 52 which results in drive torque being transferred directly between shafts 18 and 20.

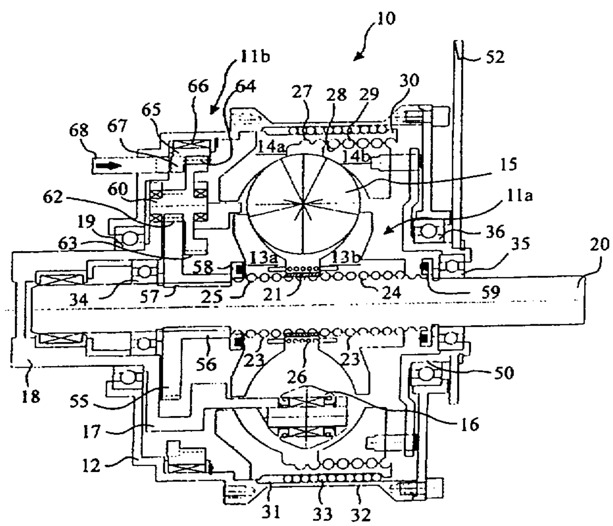

Fig. 1

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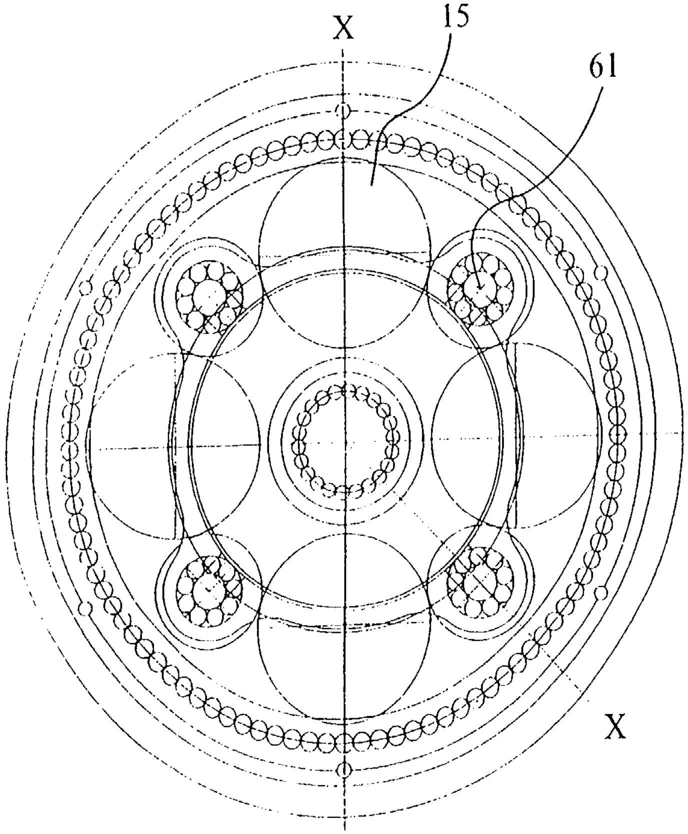
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Fig. 2

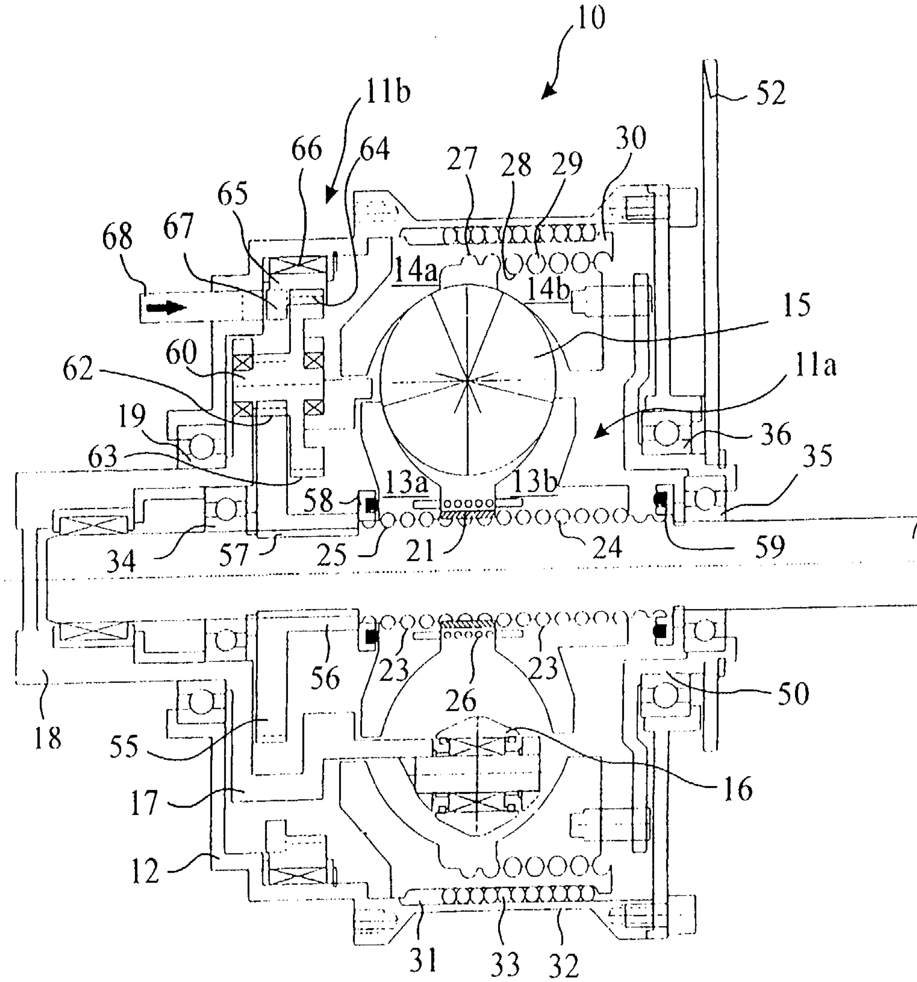
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Fig. 1

A CONTINUOUSLY VARIABLE DRIVE TRANSMISSION DEVICE

The present invention relates generally to a continuously variable drive transmission device, and particularly to a drive transmission device in which forces are transmitted by rolling traction.

In the applicant's earlier Patent Application No. PCT/GB99/00075 there is described a continuously variable drive transmission for transmitting drive between an input and an output drive member and having radially inner and outer races separated into axially spaced two parts which are relatively axially displaceable and between which are located planetary members the radial position of which is determined by the relative separation of the two parts of one of the races. The other of the races is provided with a mechanism which allows the two parts to move apart or together in order to accommodate changes in the radial position of the planetary members consequent on an adjustment in the axial separation of the two parts of the said one race. This mechanism is effectively torque sensitive in that the forces exchanged between the contacting surfaces of the races and the planetary members is varied in dependence on the torque applied between the input and output drive members.

This is achieved by means of a helical interengagement of the two members of the said "other" race in the form of a screw thread. As torque is applied the two parts of the race are caused to tend to turn in relation to one another in a sense such that the screw threaded engagement between them causes relative approach thereby increasing the contact forces between the races and the planetary members. Correspondingly, if

the torque is decreased, for a given direction of rotation, the forces on the contacting surfaces between the two parts of the "other" race and the planetary members decreases and this continues to the point where, when there is no torque, the contacting forces fall substantially to zero.

In the applicant's earlier Patent Application No. GB-A-2,354,293 there is described a similar continuously variable drive transmission in which the curved surfaces of the race parts which engage the planetary balls extend radially outwardly to a point just beyond that at which the tangent to the contact surface on the planetary ball is perpendicular to the axis of rotation of the races and the planets, which is the main axis of rotation with the transmission device itself. When the parts of the radially outer race are moved apart to allow the planetary balls to adopt their radially outermost position, corresponding to the highest gear ratio of the transmission, the point of contact between the parts of the inner race and the planetary balls lie in respective planes perpendicular to the axis of rotation. In this position with the contact points being aligned with the central axis of the planets so that there is no radial distance between the centre of the ball and the contact points, there is no inherent tendency for the balls to rotate apart from any frictional contact between the balls and the outer race due to the outward centrifugal force applied to the balls in use. The roller follower cage is provided with a set of radially outwardly extending arms which engage the radially outer surface of the respective balls. Because the roller follower cage rotates with the planetary balls the radial limitation on the position of the balls by contact with the radially outwardly extending arms causes no tendency for the balls to rotate so that they can be stationary with respect to the inner race once

the parts of the outer race have been separated to move their contacting surfaces out of contact with the planetary balls. In this configuration of the transmission there is a "direct drive" from the input shaft to the output shaft via the planetary balls, the followers and the follower cage of the transmission. In this high ratio configuration the spin and slip losses which are inevitable in the generation of intermediate ratios are not present so that the efficiency of the drive device in high ratio is increased, corresponding to the direct drive of some conventional gearboxes.

However, in a structure in which the planet ball spin/roll angular velocity ratio is high, that is to say when the transmission ratio approaches 1:1 or "direct drive", the high spin speeds tend to centrifuge lubricating fluid away from the contact zone in the region of the contact points between the planetary balls and the inner races and the low rolling speed of the planetary balls is insufficient to replenish the contact zones with lubricating fluid. This can result in metal to metal contact and premature failure of the planetary balls. It may therefore be necessary to limit top gear to a ratio lower than 1:1 and seek some means by which the torque between the input and output members can be transferred independently of the planetary balls when the transmission approaches or operates in top gear configuration.

This is achieved, according to an aspect of the invention, by a drive transmission comprising a continuously variable transmission and a non-continuously variable transmission having a common input drive member and a common output drive member in combination therewith, including a first engagement and disengagement means for disengaging at least part the drive through the continuously variable

transmission when configured for a highest gear ratio of the drive transmission, and a second engagement and disengagement means for engaging at least part of the disengaged drive through the said non-continuous transmission.

It is known that road vehicles consume the majority of fuel when top gear is selected and for some patterns of use, particularly where a large amount of motorway driving is concerned, the consumption of fuel when the vehicle is in top gear makes up for 90% or more of the total fuel used by the vehicle. Under such conditions maximum transmission efficiency is of utmost importance in order to improve fuel consumption.

According to another aspect, the invention also comprehends a drive transmission comprising a continuously variable transmission in combination with an epicyclic gear train and having common input and output drive members, the epicylic gear train having locking means for holding one rotatable element thereof stationary with respect to a stationary element of the said continuously variable transmission to provide an epicyclic gear ratio corresponding to the highest gear ratio of the said continuously variable drive transmission, whereby to transfer torque from the said input drive member to the said output drive member through the epicyclic gear train, additionally or alternatively to torque through the continuously variable transmission, in use, at the said highest ratio.

In this way it is possible for most or all of the drive torque to be transmitted from the input drive member to the output drive member via an epicyclic gear train which has a selectable ratio corresponding to that of the highest gear ratio of the continuously

variable drive transmission.

According to another aspect of the invention there is provided a drive transmission comprising a continuously variable drive transmission of the type having a plurality of planet members in rolling contact with radially inner and outer races each comprising at least two axially spaced parts, with means for selectively varying the axial separation of the two parts of the races and thereby the radial position of the planet members in rolling contact therewith to vary the transmission ratio; in combination with an epicyclic gear train having a common input drive member and a common output drive member with the said continuously variable transmission and in which a locking means is provided for holding a gear element of the said epicyclic gear train stationary with respect to the said outer race when the planet members are moved to a radial position corresponding to the highest gear ratio of the transmission, whereby to transfer torque from the said input drive member to the said output drive member through the epicyclic gear train, additionally or alternatively to torque through the continuously variable transmission, in use, at the said highest ratio.

In this way it is possible to modify the continuously variable drive transmission means of the roller contact type described in the applicant's earlier patent applications and referred to above so that at least part of the drive torque can be transmitted from the input drive member to the output drive member via an epicyclic gear train having a dedicated selectable ratio corresponding to the highest transmission ratio of the drive transmission. In this way by arranging the torque transmission to take place without the generation of relatively high contact stresses between the planetary members and

the races mechanical losses involved upon such contact and failure due to high spin speeds can be avoided. Since the contact load on the balls is reduced or eliminated when in "top gear" the balls may be made smaller and lighter without reducing fatigue life.

In a preferred embodiment of the invention, the transmission further comprises an engagement and disengagement means for disengaging the drive to the planet members when the continuously variable transmission is configured for transmission at the highest ratio, thereby to transfer torque through the said epicyclic gear train only. In this way it is possible to completely by-pass the continuously variable transmission when the transmission is configured for the highest transmission ratio by disengaging the drive to the planet members so that all the transmission torque is transferred through the epicyclic gear train. By arranging for the torque transmission to take place through the epicyclic gear train only at the highest transmission ratio greater efficiency can be achieved. Also the life of the transmission lubricating fluid can be increased and therefore the service interval of the transmission drive can be extended.

In preferred embodiments, the radius of the said outer annular gear is substantially the same as the radius of the planet member and the outer race contact points when moved to the highest gear ratio position. Preferably, the radius of the said outer annular gear is substantially the same as the radius of the planet member and the outer race contact points when the planet members are moved to the highest gear ratio position.

Preferably, the radial positions of the respective contact points of the planet members with the respective inner and outer races correspond to the respective radial inter-engagement positions of the planet gears meshing with the respective sun and annulus gears.

By arranging the operating radii of the epicyclic gears to be the same as the effective radii of the corresponding continuously variable transmission components the outer annulus gear will be stationary with respect to the outer race in top gear such that synchronous operation of the locking means may be effected to hold the outer annulus gear stationary with respect to the outer race as the planetary balls are moved radially outwards and approach their top gear position.

Preferably, the drive transmission further comprises a set of roller follower means intercalated between adjacent pairs of the said planet members and carried on the said epicyclic gear train carrier for rotation therewith. By arranging the roller follower means on the epicyclic gear train carrier a smooth transmission can be effected between the transfer of torque through the continuously variable transmission means and the epicyclic gear train when the transmission operates at the highest transmission ratio. This readily enables the drive transmission to switch between the continuously variable and epicyclic modes of operation.

In preferred embodiments, the locking member is movable to hold the annulus gear in consequence of movement of the said planet members to their radially outermost highest gear ratio position or in consequence of actuation of the said means for

varying the axial separation of the outer race parts to move the said planet members beyond their radially outermost position. In this way it is possible to actuate the movement of the locking member selectively either as a consequence of the planetary balls moving to the highest transmission ratio or "direct drive" radial position or by further attempted movement of the planetary balls beyond their radially outermost position. By arranging the locking means to operate together with the means for varying the axial separation of the outer race parts and thereby the transmission ratio selector it is possible to synchronise the movement of the locking member when the planetary balls move to their radially outermost position.

Preferably, the locking member holds the said outer annulus gear with respect to a transmission housing.

In preferred embodiments the drive transmission further comprises a bearing means between the said housing and the said outer annulus. The bearing means readily enables the outer annulus gear to rotate relative to the housing and the outer race when the planetary balls are positioned at an intermediate gear ratio position without significantly increasing the losses in the drive transmission.

Preferably, the said drive input is provided by a first rotatable shaft member which carries the said sun gear and the said inner race parts for rotation therewith, and wherein inter-engagement means are provided for mounting the said inner race parts for limited rotational movement with respect to the said first shaft member, whereby to adjust the axial separation between the inner race parts in response to adjustment

of axial separation of the outer race parts. In this way the torque applied between the input drive member and the output drive member may be in one direction or the other even for a given absolute direction of rotation of the input drive shaft and the output drive shaft as a consequence of changes in the circumstances of the machinery driven by the transmission device. For example, in a motor vehicle, for a given direction of rotation of the input shaft and the output shaft (for example in forward motion of the vehicle) the torque may be transmitted in one directional sense when the vehicle is accelerating but in the opposite directional sense when the vehicle is decelerating in a so called "engine braking" conditions.

In such a situation it is of value for the drive transmission device to be able to transmit torque in each of the two directional senses as this will allow the above mentioned engine braking effect to contribute to the decelerating forces on the vehicle when the engine output is reduced, allowing greater control of the motion of the vehicle without being entirely reliant on wheel brakes.

Preferably, the said inter-engagement means comprises respective helical engagement means between the said parts of the radial inner race and the said shaft member. The helical engagement means readily enables the inner race parts to be moved relative to one another as a consequence of relative axial movement of the outer race parts to vary the transmission ratio.

Preferably, end stops are provided at each end of the helical engagement means for limiting axial movement of the respective inner race parts with respect to the said

shaft member in both forward and reverse directions thereof. The end stops enable torque to be transferred to the inner race parts from the input drive member in both directions by reaction of a respective one of the inner race parts with the end stops on the input drive member. The end stops are preferably slightly elastic in both compressive and torsional directions to ensure free-release of the respective inner races when torque is removed, that is to say the end stops act to prevent jamming of the inner races.

An embodiment of the invention will now be more particularly described with reference to the accompanying drawings in which:

Figure 1 is an axial section review of an embodiment of the present invention in a configuration resulting in a high transmission ratio; and,

Figure 2 is a sectional view taken on the line I-I of Figure 1.

Referring now to the drawings, and particularly to Figure 1 thereof, a drive transmission device generally indicated 11 comprises a casing 12 housing continuously variable rolling traction drive transmission 11a in combination with an epicyclic gear train 11b. The rolling traction drive transmission comprises a radially inner and outer races 13, 14 axially separated into two parts 13a, 13b and 14a, 14b. Between the races 13, 14 are located planet balls 15 between which are located respective planet follower rollers 16 mounted on a follower cage or carrier 17 having a tubular axial extension 18 which constitutes one of the drive members of the device. The tubular extension 18 is borne on the casing by a bearing 19 the planets and/or the races may be made of any material capable of supporting the loads exerted on them

in use of the device, and in particular may be a ceramic material which has the benefit of having a high modulus of elasticity which gives it a high rigidity. The contact patches are therefore small and efficiency is high.

The two axially separated parts 13a, 13b of the radially inner race 13 are provided with a set of helical grooves 23 on the radially inner sides thereof. The helical grooves 23 house balls 24 which also run in corresponding helical grooves 25 formed a central shaft 20 which constitutes the other of the drive members of the device. The helical grooves 23, balls 24 and grooves 25 constitute a helical interengagement or threaded coupling between the two parts 13a, 13b and the shaft 20 allowing the two parts 13a, 13b to rotate with respect to one another with low friction provided by the balls 24, and at the same time vary their relative axial positions. A light torsion spring 26 pre-loads the two parts 13a, 13b of the inner race 13 towards one another to maintain initial contact. As an alternative, where heavy loads are involved, the balls 24 may be replaced by rollers, corresponding changes being made to the shape of the grooves. A cylindrical tubular member 21 is slidably mounted on the shaft 20 between the two parts 13a, 13b of the inner race to limit the axial movement of the parts 13a, 13b towards one another on the shaft 20. As will be explained in more detail later, this enables the drive from the shaft 20 to the balls 15 to be de-coupled when the transmission drive is in top gear, that is to say at its highest operational gear ratio. The axial length of the helical interengagement of the inner race part 13b is substantially greater than that of the inner race part 13a. The helical interengagement of the inner race part 13b is capable of transmitting higher torque loads than that of the inner race part 13a. The helical interengagement of the inner race part 13b

transmits drive torque in one direction whereas the helical interengagement of the inner race part 13a transmits braking torque in the opposite direction.

The two parts 14a, 14b of the radially outer race 14 are interengaged by a helical interengagement or threaded coupling comprising helical grooves 27 in the first part 14a of the outer race and corresponding helical grooves 28 in the second part 14b, a cross-section of these grooves being substantially semi-circular whereby to house balls 29 providing a low friction coupling between them. The first part 14a of the outer race comprises an axially extending shaft portion 30, the radially outer surface of which defines an axially extending annular cavity 31 between the shaft portion 30 and an outer cylindrical portion 32 of the casing 12. The annular cavity 31 houses a plurality of balls 33 which provide a low friction inter-engagement between first part 14a of the outer race and the casing 12 for axial movement of the first part 14a with respect to the casing 12. Axial movement of the parts 14a, 14b of the outer race is necessary so that the drive transmission device is able to transmit torque in each of the two directional senses as will be explained in more detail later.

The shaft 20 is borne on the casing 12 by two bearings 34 and 35, the former between the shaft 20 and the tubular drive member 18 and the latter between the shaft 20 and a shaft 50, one end of which projects out from the casing and carries a control lever 51 and the other end of which projects into the casing and carries a lever 52 the free end of which is secured to the second radially outer raceway part 14b. The shaft part 50 is borne on the casing by a bearing 36. Movement of the control lever 52 about the axis of the shaft 20 causes the lever 52 to turn correspondingly and thus cause the

raceway part 14b to turn about the axis of the device, which is coincident with the axis of the drive shaft 20, with respect to the fixed radially outer raceway part 14a. This movement is converted by the helical interengagement constituted by the helical channels 27 and 28 and the balls 29 into axial approach or separation of the two radially outer raceway parts 14a, 14b depending on the direction of rotation of the lever 52.

The epicyclic gear train 11b comprises a sun gear element 55, a shaft portion 56 of which is connected to the shaft 20 between the helical grooves 25 and the bearing 34 by corresponding splines 57 on the radially inner surface of the shaft portion 56 and the outer surface of the shaft 20. The sun gear element 55 is held axially stationery on the shaft 20 by engagement with the bearing 34 and an end stop 58 in the form of a locking nut at one end of the helical grooves 25. A further end stop locking nut 59 is provided at the other end of the helical groove 25 on the shaft 20 for purposes which will be explained in more detail later. The teeth of the sun gear element 55 mesh with corresponding teeth of a plurality of planet gear elements 60 which are rotatably mounted on respective shafts 61 on the follower cage or carrier 17. The sun gear element 55 meshes with a first set of teeth 62 on the planet gear elements 60 and a second set of teeth 63 axially spaced from the first set of teeth mesh with teeth 64 which constitute an inner gear of an outer annulus gear element 65. The annulus gear element 65 is borne on the casing 12 by a needle roller element bearing 66 positioned between the outer surface of the annulus gear element and the inner surface of the casing. The annulus gear element comprises a radially inwardly projecting flange 67 which includes a series of circumferentially spaced lugs or apertures for receiving one

end of an axially movable locking member 68 which is slidably mounted in a through borne aperture in the casing for engagement with a respective one of the lugs or apertures in the flange 67 to hold the annulus gear element 65 stationery with respect to the casing and thereby stationery with respect to the outer race parts 14a, 14b about the axis of the shaft 20.

Rotation of the drive shaft 20 thus causes the radially inner race parts 13a and 13b to rotate with the shaft 20 and carrying with it by rolling contact, the planetary spheres 15 which roll also over the curved surfaces of the radially outer race parts 14a, 14b. The planetary balls 15 are constrained only by their contact with the curved surfaces of the radially inner and radially outer races 13, 14 but each pair of planet balls 15 has a roller follower 16 intercalated circumferentially therebetween so that the planetary motion of the balls 15 is conveyed to these rollers and to the planet cage or carrier 17 which, in this embodiment, constitutes one of the drive members. Variation in the relative approach or separation of the radially outer race parts 14a, 14b caused by turning the control lever 51 in one direction or the other, causes a greater or lesser force to be applied to the planetary balls 15 urging them radially inwardly to contact with the radially inner race parts 13a, 13b. As the two radially outer parts 14a, 14b are brought together the forces exerted on the planetary balls 15 increases and the radially inner force applied to the radially inner races 13a, 13b urging these apart is accommodated by relative rotation of the race part 13b with respect to the race part 13a on the helical interengagement of the shaft 20.

Rotation of the drive shaft 20 also causes the epicyclic gear train 11a to rotate. In the

continuously variable mode of operation drive torque is transferred between the shafts 18 and 20 via the continuously variable transmission 11a only since the gear elements 55, 60 and 65 of the epicyclic gear train freely rotate with respect to one another. However, when the planet balls 15 are moved to their radially outermost position as shown in Figure 1, by axial separation of the outer race parts 14a, 14b, and thereby the axial approach of the inner race parts 13a, 13b, the drive torque is switched to the epicyclic gear train 11b by engagement of the locking member 68 with the outer annulus gear element 65. When the planetary balls are moved to the position shown in Figure 1 the continuously variable transmission drive 11a adopts a top gear configuration in which the radii of the respective contact points between the balls 15 and the inner race parts 13a, 13b and outer race parts 14a, 14b correspond to the respective operating radii of the epicyclic gear train between the sun gear element 55 and the planet gear element 60 and the planet gear element 60 and the outer annulus gear 65. The outer annulus gear 65 is either stationary with respect to the casing or rotating very slowly with respect thereto such that the locking member 68 may be readily moved into engagement with the apertures or lugs in the radial flange 67 to lock the annulus gear 65 such that the epicyclic gear train has a gear ratio corresponding to that of the continuously variable transmission 11a when the balls are moved to their radially outer most position as shown in Figure 1. When the locking member locks the annulus gear 65 with respect to the casing, torque is transferred between the drive members 18 and 20 by both the continuously variable transmission 11a and the epicyclic gear train 11b until drive to the balls 15 is disengaged by further movement of the lever 52 to cause the outer race elements 14a and 14b to move apart and release the balls 15 from driving engagement with the inner race parts 13a, 13b,

since further axial movement of the race parts 13a and 13b towards one another is prevented by the cylindrical tubular sleeve 21 between the two parts thereof. In this configuration drive torque is transferred directly between the drive members 18 and 20 by the now fixed ratio drive train defined by the epicyclic gear elements 55, 60 and 65. In this way losses associated with spin and slip of the balls 15 both with respect to the inner and outer race parts and the followers is eliminated and efficiency of the transmission is optimised when in the top gear configuration.

It will be appreciated that the transmission device herein described is capable of transferring drive torque in both forward and reverse directions. In the configuration of Figure 1 the first part 13a of the inner race is held axially against the end stop 58 which prevents further axial movement of the race parts 13a, 13b towards the epicyclic gear train due to the transfer of torque in one direction between the shaft 20 and the inner-race parts 13a, 13b. If the direction of applied torque is reversed the race parts move axially along the shaft 20 by means of the helical interengagement until the second race part 13b contacts the other end stop 59. At the same time the outer race parts follow the movement of the inner race parts and slide with respect to the casing on the balls 33.

Although aspects of the invention have been described with reference to the embodiment shown in the accompanying drawings it is to be understood that the invention is not limited to those precise embodiments and various changes and modifications may be effected without exercising further inventive skill. For example, although the invention has been described with reference to a continuously variable

drive transmission and an non-continuously variable epicyclic gear transmission the invention is equally applicable to other types of non-continuously variable transmission. The invention also contemplates embodiments in which the ratio of the non-continuously variable transmission is higher than the top gear, or highest, ratio of the continuously variable transmission so that a step ratio is effected in the transition from one transmission to the other. In such an embodiment it will be appreciated that it is not possible to make a synchronous shift between transmission types (continuously variable and non-continuously variable) and clutches are required instead of the dog type engagement described in the embodiment of Figure 1. The invention also contemplates embodiments in which the gear ratio provided by the non-continuously variable transmission is a different ratio from those previously described, for example, instead of the non-continuously variable transmission providing the highest gear ratio, it could provide for instance bottom, or lowest gear, or lower than bottom gear or an intermediate gear ratio of the continuously variable transmission.

In other embodiments, the drive transmission comprises more than one non-continuously variable transmission in combination with a continuously variable transmission. This type of drive transmission enables non-continuously variable operation at more than one ratio. In other embodiments, this can also be achieved with a single non-continuously variable transmission which is capable of operating at more than one ratio. In embodiments where a single non continuously variable transmission is capable of operation at different ratios it is possible to use the continuously variable transmission to avoid power interruption during shifting, a feature of considerable value in say an automotive constant mesh gearbox.

CLAIMS

1. A drive transmission comprising a continuously variable transmission and a non-continuously variable transmission having a common input drive member and a common output drive member in combination therewith, including a first engagement and disengagement means for disengaging at least part the drive through the continuously variable transmission when configured for a pre-determined gear ratio of the drive transmission, and a second engagement and disengagement means for engaging at least part of the disengaged drive through the said non-continuous transmission.

2. A drive transmission comprising a continuously variable transmission in combination with an epicyclic gear train and having common input and output drive members, the epicylic gear train having locking means for holding one rotatable element thereof stationary with respect to a stationary element of the said continuously variable transmission to provide an epicyclic gear ratio, whereby to transfer torque from the said input drive member to the said output drive member through the epicyclic gear train, additionally or alternatively to torque through the continuously variable transmission, in use, at the said highest ratio.

3. A drive transmission comprising a continuously variable drive transmission of the type having a plurality of planet members in rolling contact with radially inner and outer races each comprising at least two axially spaced parts, with means for selectively varying the axial separation of the two parts of the races and thereby the

radial position of the planet members in rolling contact therewith to vary the transmission ratio; in combination with an epicyclic gear train having a common input drive member and a common output drive member with the said continuously variable transmission and in which a locking means is provided for holding a gear element of the said epicyclic gear train stationary with respect to the said outer race when the planet members are moved to a radial position corresponding to the highest gear ratio of the transmission, whereby to transfer torque from the said input drive member to the said output drive member through the epicyclic gear train, additionally or alternatively to torque through the continuously variable transmission, in use, at the said highest ratio

4. A drive transmission according to Claim 2 further comprising an engagement and disengagement means for disengaging the drive to the planet members when the continuously variable transmission is configured for transmission at the highest ratio, thereby to transfer torque transfer through the said epicyclic gear train only.

5. A drive transmission according to Claim 3 or Claim 4 wherein the said epicyclic gear comprises a sun gear, a plurality of planet gears rotatably mounted on an epicyclic gear train carrier and an outer annulus inner gear, and whereby the said locking means holds the said outer annulus gear stationary with respect to the said outer race when the planet members are in the highest gear ratio position.

6. A drive transmission according to Claim 5 wherein the radius of the said outer annular gear is substantially the same as the radius of the planet member and the outer

race contact points when moved to the highest gear ratio position.

7. A drive transmission according to Claim 5 or Claim 6 wherein the radial positions of the respective contact points of the planet members with the respective inner and outer races correspond to the respective radial inter-engagement positions of the planet gears meshing with the respective sun and annulus gears.

8. A drive transmission according to any one of Claims 5 to 7 further comprising a set of roller follower means intercalated between adjacent pairs of the said planet members and carried on the said epicyclic gear train carrier for rotation therewith.

9. A drive transmission according to any one of Claims 5 to 9 wherein the locking member is movable to hold the annulus gear in consequence of movement of the said planet members to their radially outermost highest gear ratio position or in consequence of actuation of the said means for varying the axial separation of the outer race parts to move the said planet members beyond their radially outermost position.

10. A drive transmission according to any one of Claims 5 to 9 wherein the locking member holds the said outer annulus gear with respect to a transmission housing.

11. A drive transmission according to Claim 10 further comprising a bearing

means between the said housing and the said outer annulus gear.

12. A drive transmission according to Claim 10 or Claim 11 wherein the said locking member comprises an axially movable latch which is movable within an opening in the casing to engage the said outer annulus gear when the annulus gear stationary or substantially stationary with respect to the housing.

13. A drive transmission according to any one of Claims 5 to 12 wherein the said drive input is provided by a first rotatable shaft member which carries the said sun gear and the said inner race parts for rotation therewith, and wherein inter-engagement means are provided for mounting the said inner race parts for limited rotational movement with respect to the said first shaft member, whereby to adjust the axial separation between the inner race parts in response to adjustment of axial separation of the outer race parts.

14. A drive transmission according to Claim 13 wherein the said inter-engagement means comprises respective helical engagement means between the said parts of the radial inner race and the said shaft member.

15. A drive transmission according to Claim 14 wherein end stops are provided at each end of the helical engagement means for limiting axial movement of the respective inner race parts with respect to the said shaft member in both forward and reverse directions thereof.

16. A drive transmission comprising a continuously variable transmission and at least one non-continuously variable transmission having a common input drive member and a common output drive member in combination with the said continuously variable transmission, including a first engagement and disengagement means for disengaging at least part the drive through the continuously variable transmission when configured for a pre-determined gear ratio of the drive transmission, and a second engagement and disengagement means for engaging at least part of the disengaged drive through the or each at least one non-continuous transmission.

Application No: GB 0121330.5 23 **Examiner:** Joseph Mitchell
Claims searched: 1-16 **Date of search:** 29 January 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): F2D (DEB)

Int Cl (Ed.7): F16H 37/08

Other: Online: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 0177240	LEYLAND VEHICLES LIMITED	
A	EP 0149892	LEYLAND VEHICLES LIMITED	
A	EP 0120636	LEYLAND VEHICLES LIMITED	
A	US 6059685	HOGE ET AL	
A	US 4768398	GREENWOOD	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

DERWENT-ACC-NO: 2003-357395

DERWENT-WEEK: 200530

TITLE: Motor vehicle drive transmission has CVT rolling traction drive in combination with non-CVT epicyclic gear train

INVENTOR: MILNER P J

PATENT-ASSIGNEE: MILNER P J[MILNI] , ORBITAL TRACTION LTD[ORBIN]

PRIORITY-DATA: 2001GB-021330 (September 4, 2001)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE
GB 2379250 A	March 5, 2003	EN
GB 2379250 B	May 4, 2005	EN

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
GB 2379250A	N/A	2001GB-021330	September 4, 2001

INT-CL-CURRENT:

TYPE	IPC DATE

CIPS F16H37/08 20060101

ABSTRACTED-PUB-NO: GB 2379250 A

BASIC-ABSTRACT:

NOVELTY - The transmission (11) includes a continuously variable transmission (CVT) (11a) such as a rolling traction drive, in combination with an non-CVT (11b) such as an epicyclic gear train, with common input and output members. The drive has a first engagement and disengagement device for disengaging at least part of the drive through the CVT when configured for a predetermined gear ratio of the drive transmission. A second engagement and disengagement device engages at least part of the disengaged drive through the non-continuous transmission.

DESCRIPTION - The rolling traction drive has inner and outer races (13,14) that separate into two parts (13a,13b and 14a,14b), between which are planet balls (15). Follower rollers (16), located between the balls are mounted on a carrier (17) having a tube (18) that acts as one of the drive members of the drive device. The inner race (13) is mounted on the other drive shaft (20) in a manner to allow the two parts (13a,13b) to move towards and away from each other. The outer race parts (14a,14b) can also move towards and away from each other via rotation of a lever (52). Variation in the radial position of the balls is effected by rotation of the lever which brings the upper race parts (14a,14b) together and forces the balls towards the shaft (20), with the lower race

parts (13a,13b) moving apart due to this force. The epicyclic gear train has a sun gear (55), a number of planet gears (60) and an outer annulus gear (65). Rotation of shaft also rotates the inner race parts which causes rotation of the balls and therefore also rotation of the carrier via followers. The rotation of the shaft also rotates the epicyclic gear train. In the continuously variable mode of operation, torque is transferred between the shafts (18,20) via the CVT only, because gear elements (55,60,65) rotate freely w.r.t each other, but when the balls are moved to their outermost position, the drive torque is switched to the non-CVT by engagement of a locking member (68) to the annulus (65). In 'this top gear' configuration torque is transferred between the shafts by both the CVT and non CVT until the balls are completely disengaged by further rotation of lever which results in drive torque being transferred directly between shafts.

USE - For motor vehicle.

ADVANTAGE - Forces are transmitted by rolling action. Increased transmission efficiency.

DESCRIPTION OF DRAWING(S) - The drawing shows an axial section of the transmission in a configuration resulting in a high transmission ratio.

drive transmission (11)

CVT rolling traction drive (11a)

non CVT epicyclic gear train (11b)

races (13,14)

planet balls (15)

carrier (17)

tubular drive member (18)

central drive shaft (20)

sun gear (55)

planet gear (60)

annulus gear (65)

CHOSEN-DRAWING: Dwg.1/2

TITLE-TERMS: MOTOR VEHICLE DRIVE TRANSMISSION CVT ROLL TRACTION COMBINATION NON EPICYCLIC GEAR TRAIN

DERWENT-CLASS: Q64

SECONDARY-ACC-NO:

Non-CPI Secondary Accession Numbers: 2003-285622